Salado Flow and Transport Calculations for the CRA PA

DOE/EPA Meeting on Changes from the CCA to the CRA

April 20-21, 2004

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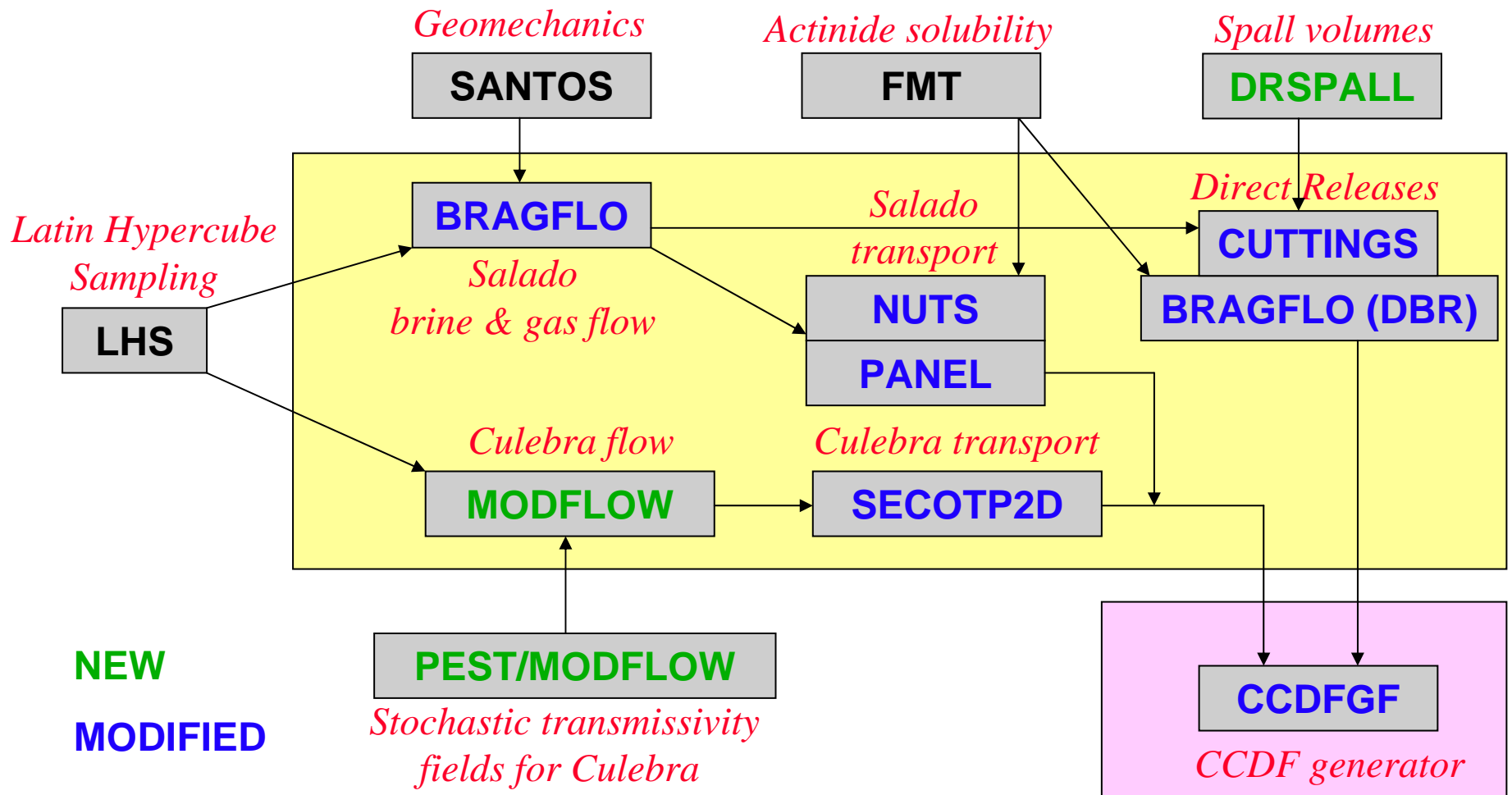**Sandia National Laboratories**

Outline

- **Salado flow and transport process models**
- **CCA BRAGFLO grid**
- **Main drivers for changes**
- **Salado Flow Peer Review**
- **CRA BRAGFLO grid changes**
- **Effects on repository performance**

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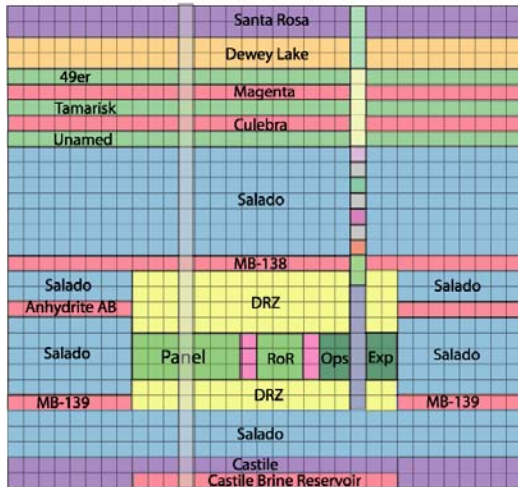
Major PA Codes in the CRA

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Flow and Transport in the Salado

- **The multi-phase flow code, BRAGFLO is used to simulate 10,000 years of brine and gas flow.**

- **The transport code, NUTS is used to simulate the transport of radionuclides within the Salado.**

- **Both codes use the same numerical grid, which represents waste panels, panel closures, shaft seals, and surrounding geology.**

- **Sub-models include: creep closure, gas generation, pressure-induced fracturing, wicking, and the Klinkenberg effect.**

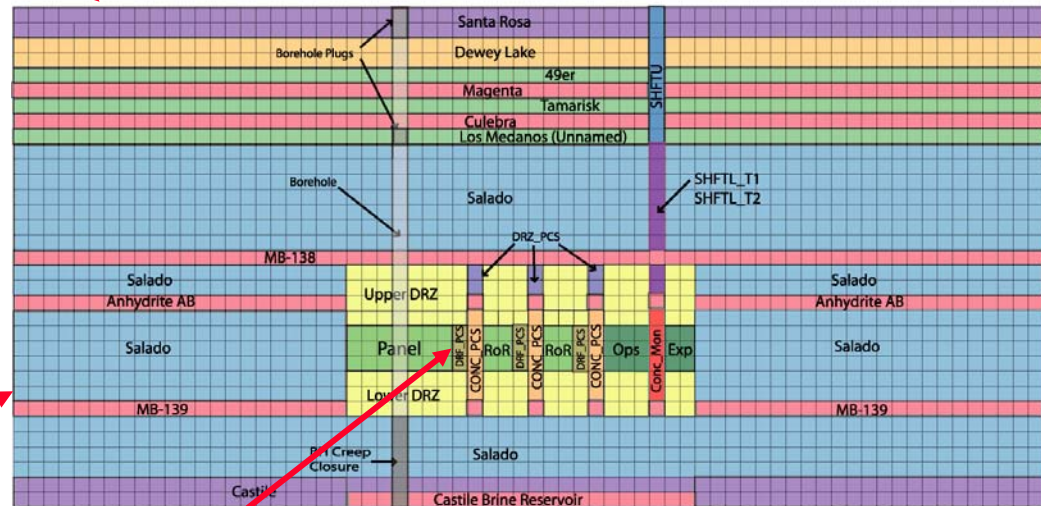- **Important output variables include: pressure, brine saturation, porosity, and brine flow as a function of time.**

4

The CRA BRAGFLO Grid

CCA → **CRA**

Increased number of Cells in X-direction

Shaft is simplified

Increased vertical refinement

Option D-Type PCS implemented with additional segmentation in waste areas

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Main Driver for BRAGFLO Grid Changes

- **Condition 1 of EPA's Final Rule:**
  - **Required DOE to implement the Option D panel closure system with Salado Mass Concrete**
- **A letter from EPA to DOE (Aug. 6, 2002):**
  - **Stated that the Option D design should be appropriately incorporated in the CRA PA calculations.**
- **Option D panel closure design is much less permeable than the generic panel closures modeled in the CCA.**

Salado Flow Peer Review

- **The Salado Flow Peer Review Panel met in April, 2002 and again in February, 2003 to review changes to three conceptual models in order that Option D panel closures could be included in the CRA (CRA Chap. 9, and Appendix PEER).**
  - *Disposal system geometry*
  - *Repository fluid flow*
  - *Disturbed rock zone*
- **After the first meeting, the panel requested that a full PA calculation be run.**
  - **Analyses were presented to the panel at the second meeting. These analyses tested various features of the new grid with the CCA inventory.**
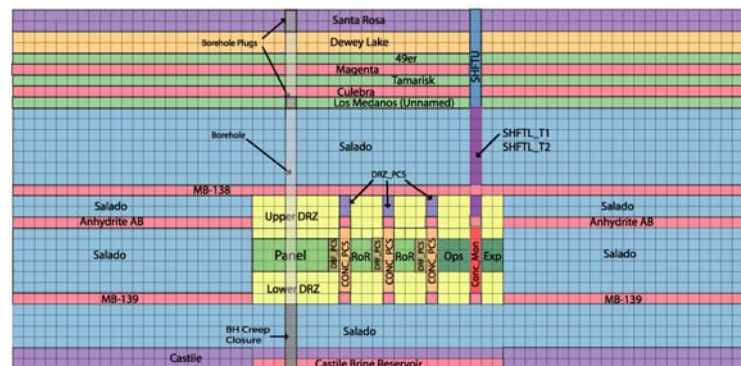
Salado Flow Peer Review

- **In addition to implementing Option D panel closure design in the BRAGFLO grid, several other issues were also addressed during the Peer Review meetings:**
  - *Simplification of the shaft seal representation*
  - *Repository horizon change to Clay seam "G"*
  - *Grid refinements and modifications*
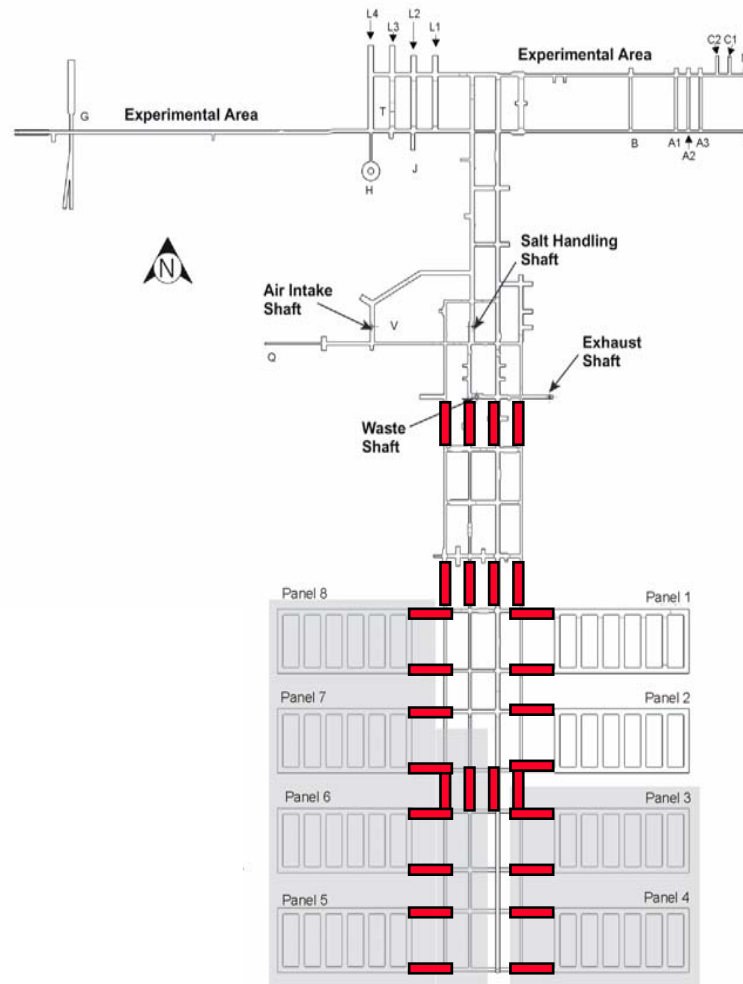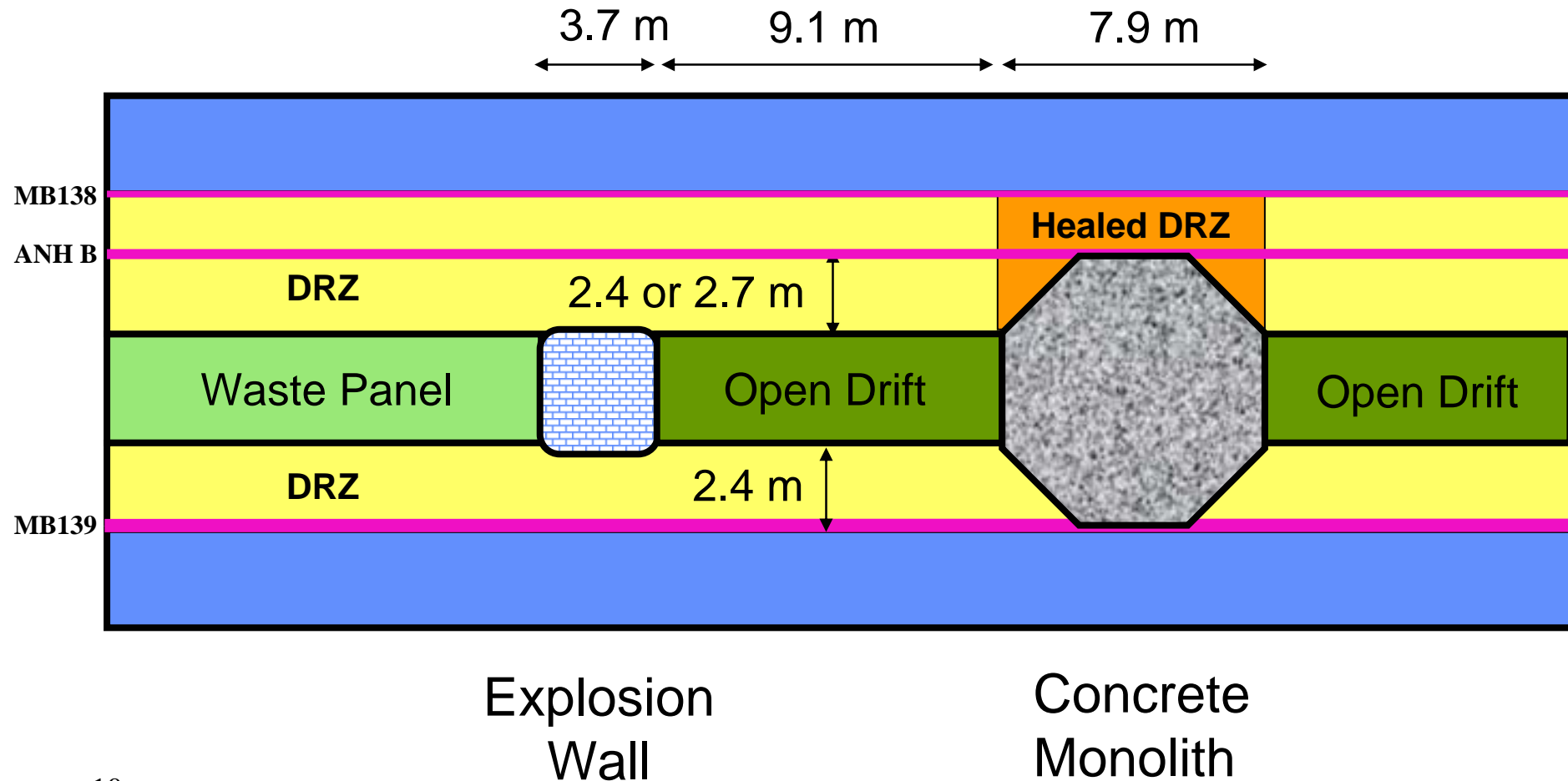 - *Changes to Direct Brine Release calculations*


CCA

CRA

Location of Panel Closures

Side View of Option D Panel Closure

(Dimensions from CCA)

Option D Panel Closures

- **Low permeability Option D panel closures can cause individual waste panels to be isolated from conditions in neighboring panels.**

  - **The pressure and saturation effects of a drilling intrusion will be localized to the intruded panel.**

• High pressures can cause fracturing in surrounding anhydrite beds and flow around the panel closures can occur.

Waste Panel A   Waste Panel B

DRZ

MB 139
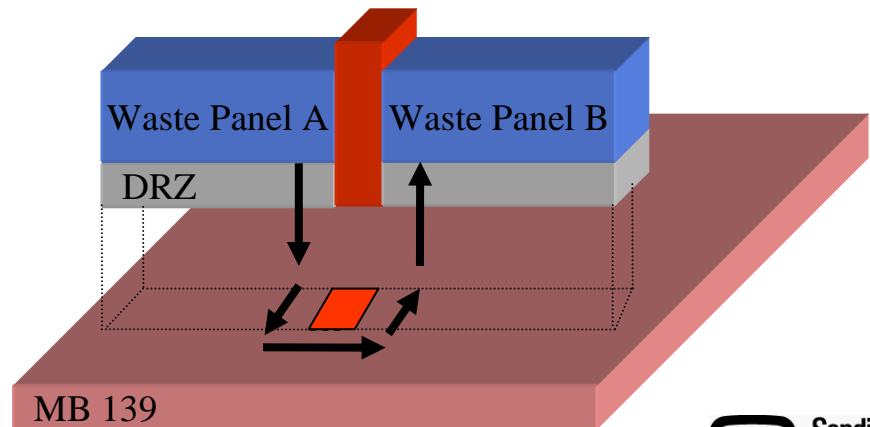
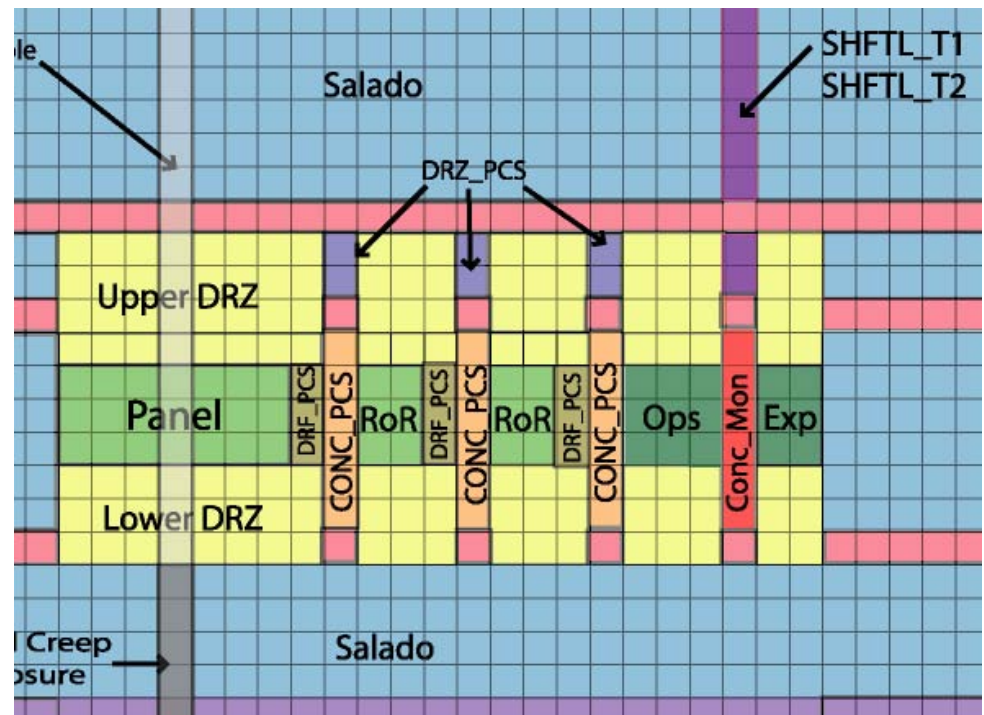# Option D Panel Closure Representation
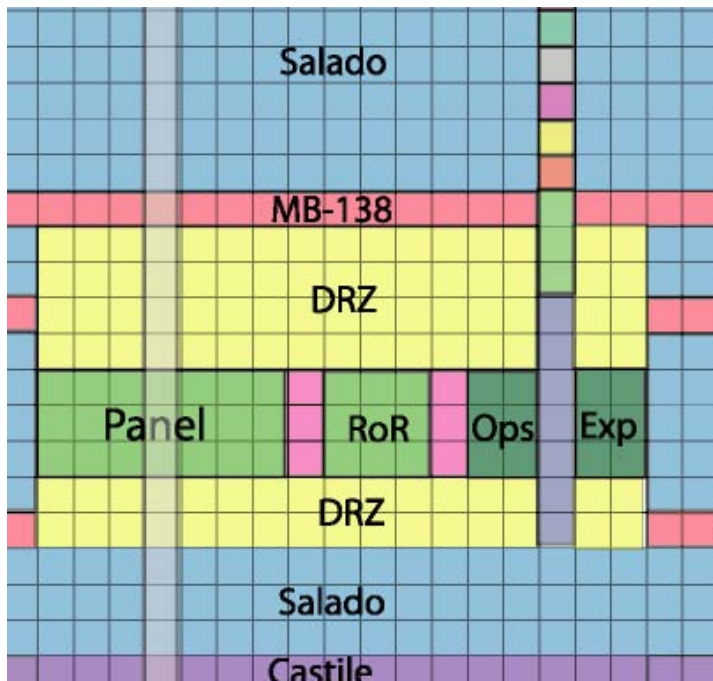
Effects of Option D on PA Results

- **Option D Panel closures do affect pressures and saturations within in the repository[1].**

  - **Panel closures delay gas movement in repository and can result in larger pressure differences in different panels over time.**

  - **Panel closures prevent brine movement except when pressures cause fracturing. This causes brine saturations to be generally lower (drier) in most parts of the repository.**

  - **Total releases are not significantly affected[2].**
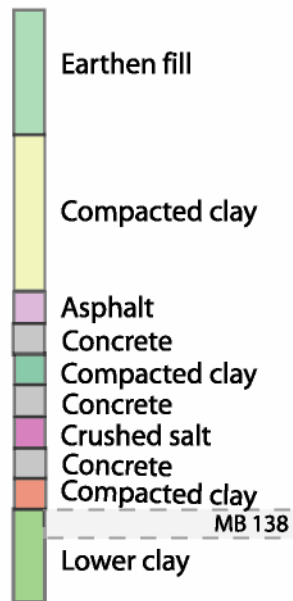
[1] Hansen, C., Leigh, C., Lord, D., and Stein, J. 2002. "BRAGFLO Results for the Technical Baseline Migration.
" Carlsbad, NM: Sandia National Laboratories. ERMS# 523209.

[2] Dunagan, S. 2003. "Complementary Cumulative Distribution Functions (CCDF) for the Technical Baseline Migration (TBM) Rev 0." Carlsbad, NM: Sandia National Laboratories. ERMS# 525707.
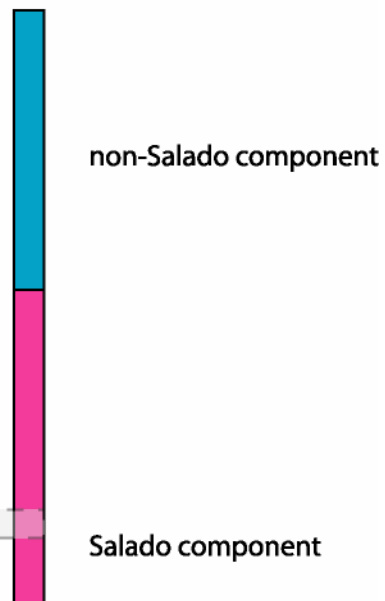
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Simplified Shaft Model

CCA Shaft Seal Model
- Earthen fill
- Compacted clay
- Asphalt
- Concrete
- Compacted clay
- Concrete
- Crushed salt
- Concrete
- Compacted clay
- MB 138
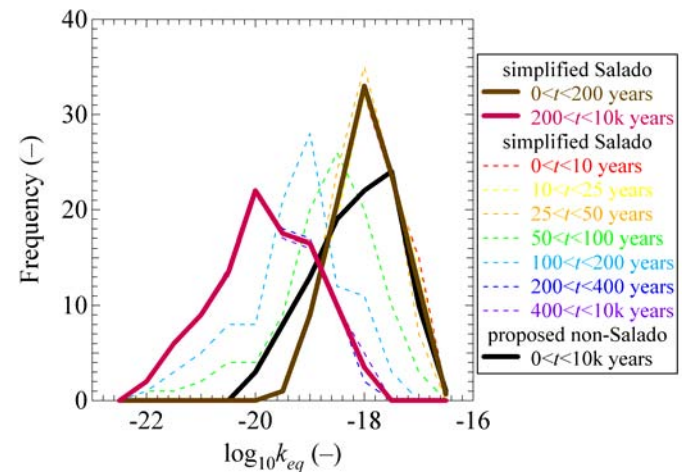- Lower clay

Simplified Shaft Seal Model
- non-Salado component
- Salado component

Not to scale

Simplified shaft model[3] uses two materials at a given time.
The effective permeability is calculated as the harmonic mean of CCA Shaft Seal Model materials

Legend:
- simplified Salado
  - $0 < t < 200$ years
  - $200 < t < 10k$ years
- simplified Salado
  - $0 < t < 10$ years
  - $10 < t < 25$ years
  - $25 < t < 50$ years
  - $50 < t < 100$ years
  - $100 < t < 200$ years
  - $200 < t < 400$ years
  - $400 < t < 10k$ years
- proposed non-Salado
  - $0 < t < 10k$ years

Axes: Frequency $(-)$ vs $\log_{10} k_{eq}$ $(-)$

14 [3] James, S.J., and Stein, J. 2003. "Analysis Report for the Development of a Simplified Shaft Seal Model for the WIPP Performance Assessment Rev 1." Carlsbad, NM: Sandia National Laboratories. ERMS# 525203.

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Clay Seam "G"

- **Aug 6, 2002: EPA sends letter to DOE: "the [Clay 'G'] conceptual change should be appropriately addressed in the modeling, if warranted"**

- **DOE evaluated possible effects of the change to repository PA calculations[4].**
  - **Porosity "surface"**
  - **Flow pathways**
  - **Pore volume**

- **DOE determined explicit inclusion of the horizon change in PA calculations was not warranted.**

[4] Stein, J., and Zelinski, W. 2003. "Analysis Report for: Testing of a Proposed BRAGFLO Grid to be used for the Compliance Recertification Application Performance Assessment Calculations." Carlsbad, NM: Sandia National Laboratories. ERMS# 526868.

Effects of Other Changes on PA Results

- CRA "simplified" shaft seal model requires far fewer parameters and essentially matches the performance of the CCA shaft seal model.
- Clay seam "G" change need not be included explicitly in PA modeling.
- Lateral grid refinement did reduce numerical dispersion in NUTS calculations.

Summary

- **Salado Flow Peer Review accepted all changes to the three conceptual models.**

- **Implementation of Option D panel closures in the BRAGFLO grid represented the most significant change, but is not important to total releases.**

- **Other changes were made but did not result in significant changes to BRAGFLO results or to total releases.**

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